UNIVERSITY OF SOUTHAMPTON

<u>ABSTRACT</u>

FACULTY OF ENGINEERING, SCIENCE & MATHEMATICS

SCHOOL OF ENGINEERING SCIENCES

<u>Doctor of Philosophy</u>

AEROACOUSTIC COMPUTATION OF SOUND RADIATION FROM DUCTS

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Modern high-bypass turbofan engines produce high levels of nuisance noise that has a significant impact on the environment near airports as well as the crew and passengers inside the aircraft. Significant research is being undertaken to understand the aeroacoustic noise source mechanisms and to accurately predict engine noise levels. High-performance computers and advanced numerical techniques are now taking an active role in this research area. In this work, a numerical solver is developed to accurately and efficiently predict noise radiation from ducts. The solver is based upon a hybrid methodology whereby only the acoustic near-field is solved using the developed numerical solver, with the resultant far-field directivity determined from an integral solution of the Ffowcs Williams - Hawking equation. Particular emphasis has been placed on the radiation of duct modes from a realistic bypass engine intake geometry.

The performance of the numerical schemes employed in the solver is analysed, with particular attention to the dispersion and dissipation qualities. A study into the determination of a suitable non-reflecting boundary condition for duct acoustics is also undertaken. Using a novel formulation of the linearised Euler equations, the solver is applied to noise radiation from a realistic engine intake geometry with background mean flow. The accuracy of the scheme is validated by comparison with analytic solutions for the unflanged duct case. For the unflanged duct case the effect of an acoustic liner is modelled using a time-domain impedance boundary condition. The effect of a locally supersonic inflow on radiation from the engine intake is examined. Finally, the solver is extended to determine multimode radiation from generic engine intakes, with the possibility to incorporate swirling mean flows and asymmetric duct geometries.